

AMENDMENTS TO THE DRAWINGS

The attached sheets of drawings include changes to Figs 1-3. These sheets, which include Figs. 1-3, replace the original sheets including Figs. 1-3.

Attachment: Replacement sheets

REMARKS

The foregoing amendment amends claims 1-2 and 4-7, cancels claims 3 and 8-14 and adds claims 15-16. Now pending in the application are claims 1-2, 4-7 and 15-16, of which claim 1 is independent.

Claim Amendments

Claims are amended to change the terms “rotary member” “casing” and “coating” to “turbine blade” “shroud” and “abradable layer,” respectively. Claim 1 is also amended to recite that no hard abrasive layer is provided on the turbine blade and the abradable layer is formed on the surface of the shroud by thermally spraying only a raw material powder sieved to have a particle size not more than 125 μm by a high velocity oxygen-fuel method. Support for the claim amendment can be found in the specification of the pending application, for example, at page 6, lines 12-15 and page 10, line 7 through page 11, line 8. No new matter is added.

Drawings

The drawings are objected to because Fig. 1 does not use hatching. In the foregoing amendments to the drawings, Fig. 1 is amended to indicate section portions of the turbine blade (38) and the shroud (40) by hatching. The drawings are also objected to because the intermediate layer recited in the claims is not depicted in the figures. In the foregoing amendments to the drawings, Figs. 2 and 3 are amended to depict the intermediate layer (41) interposed between the shroud (40) and the abradable layer (42). In light of the foregoing amendments to the drawings, Applicant requests that the Examiner reconsider and withdraw the objection to the drawings.

Specification

In the foregoing amendments to the specification, reference numeral 41 is added to describe the intermediate layer depicted in Figs. 2 and 3. No new matter is added.

Rejection of Claims 1, 3, 4, 5, 6, 8, 9, 11, 12 and 13

Claims 1, 3, 4, 5, 6, 8, 9, 11, 12 and 13 are rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent Application Publication No. 2002/0197155 (“Howard”) in view of U.S. Patent No. 5,059,095 (“Kushner”). Applicant respectfully traverses the rejection for the following reasons.

Independent claim 1 is directed to a gas turbine engine including turbine blades and a shroud. No hard abrasive layer is provided on the turbine blade for the shroud. The shroud has an abradable layer which has hardness lower than that of the material of the turbine blades. The abradable layer is formed on the surface of the shroud by thermally spraying only a raw material powder sieved to have a particle size not more than 125 μm by a high velocity oxygen-fuel (HVOF) method so as to have a porosity of 5% to 30% by volume and an oxygen content of not more than 2% by weight. Claims 4, 5 and 6 depend from claim 1 and add separate and patentable limitations. Claims 3, 8, 9, 11, 12 and 13 are canceled.

Applicant submits that Howard and Kushner do not teach or suggest that no hard abrasive layer is provided on the turbine blade for the shroud, as recited in claim 1.

Howard teaches a turbine blade having an abrasive portion, and a porous ceramic abradable seal material applied to a housing. Howard teaches that an abrasive layer is provided on a turbine blade while an abradable layer is formed on a shroud.

Kushner teaches a rotor blade tip having an abrasive coating layer and a shroud formed of a base and an abradable coating. Kushner teaches that an abrasive layer is provided on a turbine blade while an abradable layer is formed on a shroud as well.

The abrasive layer and the abradable layer are provided in direct contact with each other in Howard and Kushner. By contrast, no abrasive layer is provided on the turbine blade in the present invention. With this structure, the present invention can produce a gas turbine engine at a lower cost with a reduced number of processes. Howard and Kushner do not teach this structure of the present invention, and hence can not provide the advantages of the present invention.

Additionally, Applicant submits that Howard and Kushner do not teach or suggest that the abradable layer is formed on a surface of the shroud by thermally spraying only a raw material powder sieved to have a particle size not more than 125 μm by a high velocity oxygen-fuel method so as to have a porosity of 5% to 30% by volume and an oxygen content of not more than 2% by weight, as recited in claim 1.

Howard teaches that a ceramic particle is less than about 200 μm in size and mixed with up to 1.5% by weight of polyester to provide the porosity of 5% to 15%. Howard teaches that the mixture is then plasma sprayed on a turbine housing to form an abradable seal. See Howard, paragraphs [0010] and [0011]. Although the Howard reference teaches the porosity and the particle size of the seal material mixture, Howard does not teach that the seal material has an oxygen content of not more than 2% by weight, as recited in claim 1.

Kushner is cited by the Examiner to provide teachings for the HVOF method. In the Office Action, the Examiner asserts that the HVOF method used in Kushner inherently introduces or produces an oxygen content. See the Office Action, page 4, lines 1-2 and 10-11. Kushner teaches that a ceramic layer can be formed on the tip (26) of the blade as a HVOF sprayed coating. Kushner also teaches that a plasma spray method is used to form the abradable coating (24) on the shroud (20). See Kushner, Abstract and column 3, lines 3-6. Kushner, however, does not teach that the abradable coating (24) is formed as a HVOF sprayed coating. In Kushner, an oxygen content can be introduced at most to the ceramic layer on the tip of the blade, not to the abradable coating. Furthermore, Kushner does not teach that the oxygen content is not more than 2% by weight, as recited in claim 1. Kushner does not teach a specific limit of the oxygen content, such as 2% by weight as recited in claim 1.

Additionally, Applicant submits that those of ordinary skill in the art would not be motivated to combine the teachings of Howard and Kushner. The Examiner asserts in the Office Action that a person skilled in the art would apply the abradable coating of Howard using the HVOF method taught in Kushner for the purpose of producing a dense coating. Applicant respectfully disagrees.

Kushner provides a rotor blade having improved friction characteristics against a shroud material, and improved abilities to abrade the shroud material. Although Kushner teaches a

HVOF method for forming an abrasive coating layer on the blade, those skilled in the art would not be motivated to use the HVOF method to form the abradable layer on the shroud in Howard because the abrasive coating layer is completely different from the abradable coating on the shroud.

Howard teaches a plasma spray method for forming the abradable layer on the shroud. Two conditions, durability (or strength) and abradability, are required for the abradable layer formed on the shroud. On the other hand, the abrasive coating layer requires high strength and wear-resistance. Since these two layers have totally different characteristics, a person skilled in the art would not be motivated to form the abradable coating of Howard by the HVOF method used to form an abrasive layer in Kushner. Howard teaches that the plasma spray method is required to obtain the abradable layer with the porosity of 5 to 15%.

In Howard, the mixture of polyester and ceramic particles is used for the plasma spraying method. If the abradable coating of Howard is formed by the HVOF method taught in Kushner, organic components in polyester may produce impurities such as carbon on the coating during decomposition. Therefore, the ordinary artisan would not be motivated to form the abradable coating of Howard by a HVOF method taught in Kushner.

In light of the foregoing arguments, Applicant submits that the Examiner fails to establish a *prima facie* case of obviousness. Therefore, Applicant requests that the Examiner reconsider and withdraw the rejection of claims 1, 3, 4, 5, 6, 8, 9, 11, 12 and 13 under 35 U.S.C. §103(a), and pass the claims o allowance.

Rejection of Claims 1, 2, 3, 5, 8, 9, 10 and 11

Claims 1, 2, 3, 5, 8, 9, 10 and 11 are rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 6,233,822 (“Grossklaus”) in view of U.S. Patent Application Publication No. 2002/0197155 (“Howard”). Applicant respectfully traverses the rejection for the following reasons.

In the foregoing amendments, claims 3, 8, 9, 10 and 11 are canceled. Claims 2 and 5 depend from claim 1 and add separate and patentable limitations to claim 1. Applicant submits

that Grossklaus and Howard do not teach or suggest that no hard abrasive layer is provided on the turbine blade for the shroud, as recited in claim 1.

Grossklaus teaches a method for repairing the shroud surface of a gas turbine engine. In Grossklaus, an abradable coating is formed on a shroud. Grossklaus, however, does not teach that no abrasive layer is provided on the turbine blade, as recited in claim 1.

Additionally, Applicant submits that Grossklaus and Howard do not teach or suggest that the abradable layer is formed on a surface of the shroud by thermally spraying only a raw material powder sieved to have a particle size not more than 125 μm by a high velocity oxygen-fuel method so as to have a porosity of 5% to 30% by volume and an oxygen content of not more than 2% by weight, as recited in claim 1.

The Examiner recognizes that Grossklaus does not teach the particle size and the porosity of the material. The Examiner cites Howard to compensate for the deficiencies of Grossklaus. Howard teaches that the ceramic particle is less than about 200 μm in size and mixed with up to 1.5% by weight of polyester to provide the porosity of 5% to 15%. Although the Howard reference teaches the porosity and the particle size of the seal material mixture, Howard does not teach that the seal material has an oxygen content of not more than 2% by weight, as recited in claim 1.

Additionally, Applicant submits that those of ordinary skill in the art would not be motivated to combine the teachings of Grossklaus and Howard. The Examiner asserts in the Office Action that it is obvious for a person having ordinary skill in the art to modify the material of Grossklaus to be 20 to 125 μm in size, as taught in Howard, which enables the porosity of a 5% to 15% by volume. Applicant respectfully disagrees.

Howard teaches that the abradable coating layer is formed by the plasma spraying method, while Grossklaus teaches that a repair coating is formed by the HVOF method. The prerequisites for forming the coatings of Howard and Grossklaus are different from each other, and hence the skilled artisan would be motivated to combine the teachings of Howard and Grossklaus.

In order to provide a porosity of 5% to 15%, Howard teaches that the ceramic particles are less than about 200 μm , preferably about 20 to 125 μm , in size and mixed with up to 1.5% by weight of polyester. In combination of Howard and Grossklaus, it is required to mix polyester as an organic material and a raw material for the coating as inorganic material to obtain the porous abradable coating layer. Preparation of such mixture is time consuming and requires a high production cost. Furthermore, the organic components in polyester may produce impurities, such as carbon, which tend to remain in the coating. Therefore, it is likely to cause deterioration in durability of the abradable coating layer.

In contrast, the present invention uses only raw material, impurities are prevented from being mixed in the abradable layer. The present invention also provides an abradable layer that has an oxygen content of not more than 2% by weight. Accordingly, the formed abradable layer is not easily peeled from the shroud, and improved in oxidation resistance. The abradable layer of the present invention therefore provides excellent weather resistance. The present invention provides the advantages that the abradable layer has improved reliability with lower production cost and reduced production processes.

In light of the foregoing arguments, Applicant submits that the Examiner fails to establish a *prima facie* case of obviousness. Therefore, Applicant requests that the Examiner reconsider and withdraw the rejection of claims 1, 2, 3, 5, 8, 9, 10 and 11 are rejected under 35 U.S.C. §103(a), and pass the claims o allowance.

Rejection of Claims 7 and 14

Claims 7 and 14 are rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 6,233,822 ("Grossklaus") in view of U.S. Patent Application Publication No. 2002/0197155 ("Howard"), further in view of an engineering expedient. Applicant respectfully traverses the rejection for the following reasons.

In the foregoing amendments, claim 14 is canceled. Claim 7 depends from claim 1 and adds separate and patentable limitations to claim 1. The Examiner notes that the limitations recited in claim 7 are obvious to a person having ordinary skill in the gas turbine engine art.

Based on the arguments set forth above, Applicant submits that Grossklaus, Howard and the engineering expedient do not teach or suggest that no hard abrasive layer is provided on the turbine blade for the shroud, as recited in claim 1. Applicant also submits that Grossklaus, Howard and the engineering expedient do not teach or suggest that the abradable layer is formed on a surface of the shroud by thermally spraying only a raw material powder sieved to have a particle size not more than 125 μm by a high velocity oxygen-fuel method so as to have a porosity of 5% to 30% by volume and an oxygen content of not more than 2% by weight, as recited in claim 1.

In light of this, Applicant submits that Grossklaus, Howard and the engineering expedient do not teach all of the limitations of claim 1. Claim 7, which depends from claim 1, is not rendered obvious over the cited prior art references. Therefore, Applicant requests that the Examiner reconsider and withdraw the rejection of claim 7 under 35 U.S.C. §103(a), and pass the claim to allowance.

New Claims


Applicant adds new claims 15 and 16 to depend from claim 1 and clarify the scope of the claimed invention. Support for the new claims can be found in the original claims and descriptions in the specification, for example, at page 11, lines 1-8. No new matter is added. In light of the arguments set forth above, Applicant submits that new claims 15 and 16 recite patentable subject matter, and requests that the Examiner pass the claims to allowance.

Conclusion

In view of the above amendment, applicant believes the pending application is in condition for allowance.

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Respectfully submitted,

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